REMARKS/ARGUMENTS

Claims 1, 3-6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Seidl et al. (US 2004/0146655 A1) in view of Schrems (US 6,580,110). Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Seidl et al. taken with Schrems, and further in view of Van Wijck (US 6,585,828). Claims 1-6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Divakaruni et al. (US 6,309,924) in view of Lee et al. (US 6,468,924).

1. Rejections of Claims 1, 3-6 under 35 U.S.C. 103(a):

Claims 1, 3-6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Seidl et al. in view of Schrems, for reasons of record that can be found on pages 2-3 in the Office action identified above.

Response:

The Applicant intends to point out the differences between claim 1 of the present application and the applications of Seidl et al. and Schrems. Therefore, claim 1 of the present application is repeated below:

"1. A method for fabricating a bottle-shaped deep trench comprising:

providing a substrate having a pad layer thereon;

etching the pad layer and the substrate to form a deep trench, the deep trench having a sidewall and a bottom surface;

performing an atomic layer deposition (ALD) process to form a nonmetal layer on the

pad layer and on an upper portion of the sidewall of the deep trench; and

performing an isotropic etching process by taking the nonmetal layer as a hard mask to remove a portion of the sidewall and the bottom surface of the deep trench not covered by the nonmetal layer so as to form a bottle-shaped deep trench."

According to claim 1, the main characteristics of the present application comprises *forming an ALD nonmetal layer (nitride or oxide layer) directly on the upper portion of the sidewall of the deep trench, the ALD nonmetal layer exposing the lower portion of the trench sidewall and bottom of the deep trench, and performing an isotropic etching process by taking the ALD nonmetal layer as an etching mask to remove a portion of the sidewall and the bottom surface of the deep trench to form a bottle-shaped deep trench.* Then, the ALD nonmetal layer is removed to continue fabricating the trench capacitor. Therefore, the ALD nonmetal layer is used only for being a sacrificial etching mask but not a collar oxide layer of a trench capacitor.

Referring to the application of Seidl et al., they disclose how to form a silicon dioxide layer on a vertical surface so that to form a collar oxide layer on an upper portion of a deep trench. As shown in Figs.2A-2G, the trench 8 is firstly lined completely with a covering layer 17 by a thermal oxidation (para. [0043]). Then, a starter 18 is formed on the upper portion of the deep trench 8 by restricting a process quantity to restrict the growth depth of the starter 18, wherein the starter layer 18 comprises aluminum (Fig.1A and para. [0044], lines 7-11). Tris(tert-butoxy)silanol ($(^tBuO)_3SiOH$) is following introduced to replace methyl groups of the starter 18 so as to form a siloxane layer 19 on the starter 18 (para. [0041], lines 11-20, and [0046]). Then, the formation of a starter layer 18 and siloxane layer 19 is repeated a number of times. After crosslinking of the siloxane layers 19, a silicon dioxide layer 20, with small quantities of aluminum resulted from the above-mentioned formation process, is formed (para. [0047], lines 1-12). Referring to Figs.2F-2G, the silicon dioxide layer 20 is a collar oxide layer of a trench capacitor.

Accordingly, although the Examiner considers the silicon oxide 20 is the same as the *ALD **nonmetal layer*** of the present application, *the silicon dioxide layer 20 is not fabricated by an ALD process, but is fabricated by repeating forming starter layers 18 and introducing $(^tBuO)_3SiOH$ many times, and crosslinking, which results an **aluminum-containing** silicon oxide layer 20.*

In addition, before forming the silicon oxide layer 20, a covering layer 17 is firstly formed on the whole trench sidewall by a thermal oxidation process. Therefore, *the silicon oxide layer 20 is not formed directly on the trench sidewall and does not directly contact the trench sidewall.* Furthermore, *the silicon oxide layer 20 is used for being a collar oxide layer, which will be kept to be a part of the trench capacitor in the following fabricating process (Fig. 2G), rather than being a sacrificial etching mask* which will be stripped after the etching process. Accordingly, the functionality and fabrication steps of the silicon oxide layer 20 are quite different from those of the sacrificial ALD nonmetal

layer of the present application.

Referring Schrems's application, he teaches fabricating a vertical capacitor structure with a non-conformal collar oxide layer. In the embodiment, he discloses performing a PECVD process or a LPCVD process to form a non-conformal (with thick upper portion and thin lower portion) silicon nitride layer above an oxide layer on an upper portion of the deep trench. Then, the silicon nitride layer is used as an etching mask to remove the oxide layer not covered by the silicon nitride layer so as to form a collar oxide layer.

Since Schrems teaches taking the silicon nitride layer as an etching mask, *he doesn't disclose performing an ALD process to form the silicon nitride layer*. In addition, the silicon nitride layer serving as the etching mask is only used to etching the oxide layer for forming the collar oxide layer, but not to etching the sidewall of the deep trench. In contrary, Schrems removes the silicon nitride layer before etching the trench sidewall by taking the collar oxide layer as an etching mask.

To conclude the above discussion, *neither Seidl et al. nor Schrems teach taking a simply ALD process to fabricate a nonmetal layer only on the upper portion of the trench stdewall.* And *both the nonmetal layer (silicon dioxide layer 20) of Seidl et al. and the non-conformal layer are formed above an oxide layer on the trench sidewall,* whereas the ALD nonmetal layer of the present application is directly formed on the trench sidewall with directly contacting the trench sidewall. Furthermore, *the silicon dioxide layer 20 of Seidl et al. is kept to be a collar oxide layer, which is a part of the trench capacitor, and the non-conformal layer of Schrems is used for removing a portion of the oxide layer, rather than the trench sidewall.* Therefore, the formation steps of the collar oxide layer and functionalities in Seidl et al. or Schrems's applications are quite different from the method to form a bottle-shaped trench of the present application. Applicants believe it is not obvious to one ordinary skill in the art to modify Seidl et al. and Schrems to observe

the method of the present application.

MPEP 706.02(j) explains very clearly that three criteria must be met to sustain an obviousness-type rejection: (1) there must be some sort of motivation to combine the references, (2) there must be a reasonable expectation of success, and (3) all claim limitations must be met. Applicants respectfully asserts that none of these three criteria are met to sustain a 35 U.S.C. 103(a) rejection against claim 1 when combining Seidl et al. with Schrems's applications. Therefore, reconsideration of claim 1 is politely requested.

Claims 3-6 are dependent upon claim 1. Therefore they should be allowable if claim 1 is allowable. Reconsideration of claims 3-6 is hereby requested.

2. Rejections of claim 2 under 35 U.S.C. 103(a):

Claim 2 is rejected under 35 U.S.C. 103(a) as being unpatentable over Seidl et al. taken with Schrems as applied to claims 1, 3-6, and further in view of Van Wijck (US 6,585,823), for reasons of record that can be found on pages 3-4 in the Office action identified above.

Response:

Since claim 2 is dependent upon claim 1, it should be allowable if claim 1 is allowable. Reconsideration of claim 2 is politely requested.

3. Rejections of claims 1-6 35 U.S.C. 103(a):

Claims 1-6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Divakaruni et al. in view of Lee et al, for reasons of record that can be found on pages 4-5 in the Office action identified above.

Response:

Divakaruni et al. teach forming a silicon nitride layer 81 *on the whole trench sidewall and bottom of the trench* after forming the deep trench, and sequentially depositing an amorphous silicon layer 83 and an nitride layer 85 on the silicon nitride layer 81. Then the upper portion of the nitride layer 85 is removed to expose the amorphous silicon layer 83, which is following thermally oxidized for forming a collar oxide layer 89 on the upper portion of the trench sidewall. The collar oxide layer 89 is then taken as a mask to remove the nitride layer 85, amorphous silicon layer 83, and silicon nitride layer 81 in the lower portion of the trench. Then, selectively, NH_4OH may be used as an etching agent to further etch the lower trench sidewall to complete the formation of the collar oxide layer 89.

Accordingly, *the silicon nitride layer 81 of Divakaruni et al. is used for being a barrier layer of thermal oxidization process and improving the thickness uniformity of the deposited amorphous silicon layer 83 and the resulting collar oxide layer 89* (col. 6, lines 17-23), not for being an etching mask as the ALD nonmetal layer of the present application. In addition, although the collar oxide layer 89 can be used as an etching mask for etching the trench sidewall, it is formed through at least five different formation processes and other sacrificial layers, such as the oxide layer 85, and the collar oxide layer 89 will be kept to be a part of the trench capacitor. Therefore, it is quite different from the sacrificial etching mask of the present application, which is formed on the upper portion of the trench sidewall *only by an ALD process.*

Referring the application of Lee et al., they only teach forming a silicon nitride layer on a horizontal surface by an ALD process with preferable step coverage, but are silent about forming a nonmetal layer only on a portion of a vertical surface or a trench sidewall by ALD processes for being an etching mask. Accordingly, the Applicants believe there is no reason, and is not obviously, to combine the applications of Divakaruni et al. and Lee et al. to finish the present application. Therefore, reconsideration of claims 1-6 is politely requested.

4. **Addition of new claims 7-8:**

For further defining the present application, claims 7-8 are added. Claim 7 defines the ALD nonmetal is removed after etching the trench sidewall to form the bottle-shaped deep trench according to paragraph [0020], lines 7-8. Claim 8 defines the ALD nonmetal layer is directly formed on the sidewall of the deep trench and contacts the upper portion of the sidewall of the deep trench according to Fig.6 and paragraphs [0016]-[0017]. Consideration of claims 7-8 is politely requested.

Applicants respectfully request that a timely Notice of Allowance be issued in this case.

Sincerely yours,

Winston Hsu

Date: February 15, 2005

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Note: Please leave a message in my voice mail if you need to talk to me. The time in D.C. is 13 hours behind the Taiwan time, i.e. 9 AM in D.C. = 10 PM in Taiwan).